ALLOY-COATED BOILER PART AND METHOD OF WELDING SELF-FLUXING ALLOY-COATED BOILER PART

TECHNICAL FIELD

[0001]

The present invention relates to a boiler part such as a tube part (hereinafter, referred to as "boiler tube") constituting a heat transfer tube in various types of boilers, or a plate material-tube material composite panel (hereinafter, referred to as "boiler furnace panel") constituting a furnace housing with a cooling-water passage, and more specifically to a boiler part with alloy coating for improving durability and suitable to the welding, and a method of welding an alloy-coated boiler part.

BACKGROUND ART

[0002]

Firstly, when exemplifying the boiler tube, in the days when the operation temperature of the boiler is lower than that in these days, and erosion/corrosion environment inside the furnace is not so severe, that the steel tube for boiler (low alloy steel tube) taking into consideration of high temperature usability with respect to mechanical characteristics is made to be used in bare state is an ordinary use mode. The stainless tube, and further the titanium tube are used for the application of requiring corrosion resistance, however since coming expensive, not be in heavy use.

[0003]

In recent years, a boiler with the form of recovering and utilizing refuse incineration heat increases, thereby in particular, problem of erosion (wear) caused by combustion ash dust occurs, as a countermeasure for this problem, a

specification for applying thermal spray coating of self-fluxing alloy (first alloy material) excelling in erosion resistance are started to be in heavy usage.

However, the above described self-fluxing alloy coating is the coating which is left subjected to the thermal-sprayed formation by, for example, HVOF (High Velocity Oxygen Fuel) thermal spraying apparatus (that is, it is porous coating, so pinholes reaching base metal exist. Hereinafter, referred to as "unmelted coating"); a self-fluxing alloy coating subjected to the melting process after thermal spraying heavily used in other application (for example, rollers for metal sheet processing line)(which the self-fluxing alloy coating is modified from the porous coating into the dense coating, is the coating provided with sufficient environment blocking function with the above pinholes lost, and is the example of the "weld deposition coating"), application of such self-fluxing alloy coating subjected to the melting process after thermal spraying is uncommon.

[0004]

The reason why the application of the weld deposition coating of the self-fluxing alloy for the boiler tube is uncommon is that extraordinary difficult work is required in which since the thermal shock cracking is easy to occur for the boiler tube on its weld deposition coating caused by rapid local temperature rise at the time of the welding operation when the boiler tube is welded to be joined for use, the whole tubes are subjected to preheating inside the furnace, then the tube with high temperature is made to be joined by the welding.

However, as for the boilers in recent years, the problems concerning not only erosion but also corrosion become important together with high-temperature burning request for making exhaust air harmless, thus weld deposition coating application to the boiler is increasingly desired earnestly in the form of provision of prefabricated coating portion.

[0005]

As one example thereof, constitution that the weld deposition coating of the self-fluxing alloy is applied to the boiler tube is disclosed in the patent document 1 (Japanese Patent Application Laid-Open (JP-A) No. 10-170194). Then, here there is adopted constitution in which a non-thermally sprayed portion of about 50 mm is provided at an end portion of the boiler tube which the non-thermally sprayed portion is taken to as a joint margin (page 3, the fourth column, lines 15 to 16, in the patent document 1). Further, on the above non-thermally sprayed portion, after the welding, process of fitting a protector member instead of the coating is added (the fourth column, lines 24 to 26). The above process requires special order of the protector member (for example, protector member made of alumina) provided with the excelling in erosion resistance, or fitting operation inside narrow boiler, therefore, it is necessary for the process to prepare high cost in material and work, and front loaded procurement of the materials.

[0006]

In addition to this, technique that after the weld joint a self-fluxing alloy non-thermally sprayed coating boiler tube prefabricated inside the factory at the construction site, melting process due to the induction heating or the like is made to be applied at that location can be considered, however, it is impossible practically caused by the narrow space or heating difficulty of the interfaced portion with the other members.

By the way, since, in the melting process of the self-fluxing alloy, reheating-crack occurs when the entire simultaneous melting or one direction melting is not performed, the induction heating is indispensable for execution at that location.

[0007]

Next, in the case of the boiler furnace panel, since it is composite constitution in which tube materials and plate materials are arranged alternately as described above, or it has large dimension (for example, 0.5m × 6m), use of practical supplemental member corresponding to the above protector is more difficult, further there is the problem of the complicated shape distortion together with the melting process after the thermal spraying (see the patent document 2 or the patent document 3), thus the condition is that utilization of the prefabricated melt-coating product itself is difficult to consider.

[0008]

Patent Document 1: JP-A No. 10-170194

Patent Document 2: JP-A No. 2001-4101

Patent Document 3: JP-A No. 2000-329304

DISCLOSURE OF THE INVENTION

Problem to be solved by the Invention

[0009]

The first problem is to provide an alloy-coated boiler part that at all regions to be protected, is subjected to a weld deposition coating of alloy material excelling in erosion/corrosion resistance and that even when joined by the welding, is free from thermal shock cracking.

Further, the second problem is to provide a method of welding a self-fluxing alloy coated boiler part in which the welding for joining the boiler part to which the weld deposition coating of the self-fluxing alloy is applied at all regions can be performed free from thermal shock cracking.

Means for Solving the Problems

[0010]

The alloy coated boiler part according to the present invention described in claim 1 is devised for solving the above mentioned first problem, characterized in that an alloy coated boiler part which is constituted such that a coating composed of an alloy material occupied by an Ni (Nickel)-enriched Ni-Cr (chromium) component over a half proportion of the alloy material is applied to a base metal, and which the alloy coated boiler part is used by being welded to be joined, a weld deposition coating composed of said alloy material (the second alloy material) in which contents of B (Boron) and Si (Silicon) being melting point lowering elements are suppressed such that B is 0.1% or less and Si is weight ratio 0.5% or less is applied over rapid temperature rise region, where thermal shock cracking may occur at the welding operation, at end portions subjected to weld joint including the vicinity thereof, on the other hand, a weld deposition coating (desirably after-thermally sprayed melt-coating) composed of said alloy material (the first alloy material) of composition in which contents of B and Si are in the range of 1 to 5% respectively (any of 1% or more and 5% or less) is applied on any remaining regions other than the rapid temperature rise region. By the way, as for a forming means of the weld deposition coating composed of the above second alloy material, there can be exemplified the weld building-up (one layer building-up of importance given to cost, or two layers building-up of importance given to component purity), however, being not limited to this method.

[0011]

Further, a method of welding a self-fluxing alloy coated boiler part according to the present invention described in claim 8 is devised for solving the above mentioned second problem, being a method of welding self-fluxing alloy coated boiler part to which a weld deposition coating (desirably after-thermally

sprayed melt-coating) composed of a self-fluxing alloy material (the first alloy material) occupied by an Ni-enriched Ni-Cr component over a half proportion of the alloy material and further occupied by B and Si in the range of 1 to 5% respectively is applied to a base metal, the method comprising the steps of: forming a gradation preheated region, with end portions subjected to the welding as the objects, upon applying preheating process having a heating pattern where an amount of temperature raising gradually reduces inward from the end portions by using slow heating condition that speed of temperature raising at said end portions is 2 to 10°C/sec; and performing a welding operation (desirably, with the second alloy material occupied by an Ni-enriched Ni-Cr component over a half proportion of the alloy material and the contents of B and Si are suppressed such that B is 0.1% or less and Si is weight ratio 0.5% or less) of said end portions continuously. By the way, in the above welding operation, also a weld building-up operation for the end portion of single part and weld joint of the end portions of neighboring parts are included.

Effect of the Invention

[0012]

The alloy coated boiler part described in claim 1 is constituted such that the weld deposition coating composed of the alloy material (the first alloy material) having fusibility with melting point lowering elements sufficiently mixed at the most area except for the end portion is applied, as for the end portion, thus manufacture in a factory with high productivity and low cost in the same as ordinary thermal spraying-melting process can be performed. On the other hand, the end portion region has no choice but to depend on high implementation other than the thermal spraying such as the weld building-up or the like with low productivity, however, since the region area is small, it is possible to manufacture

with low cost as a entire.

The thermal spraying coating of the end portion region keeps the mixing amount of B, Si to a minimum, that is, the thermal coating is composed of the second alloy materials, therefore, there is no fusibility, thus high implementation productivity cannot be desired, however, instead of this, the end portion region is free from the thermal shock cracking sensitivity which the alloy material sufficiently mixed with B and Si has.

With respect to durability, since the both coatings are the thermal spraying coatings, the environment blocking property is sufficient, further, also the corrosion resistance of the coating itself is significantly excellent due to high Ni-Cr composition. With respect to erosion resistance, the most region coating to which large amount of B, Si are mixed excels, however, it has no great difference, a treatment to a degree of adding difference to an initial coating thickness is capable of approximately equalizing the erosion resistance.

As described above, the first problem is solved.

[0013]

According to the method of welding the self-fluxing alloy coated boiler part of claim 8, as for the thermal shock cracking of the self-fluxing alloy thermally sprayed coating generated caused by rapid temperature rise at the time of the welding, it is possible to minimize rapid change amount of temperature accompanied with the rapid temperature rise over the entire region, thus the thermal shock cracking is not generated by providing "gradation preheated region" in such a way as to involve filler metal application region.

The above described welding method is available when necessity of rapid adjusting the alloy coated boiler part of constitution of claim 1 due to a unexpected condition such as dimension collaboration in the boiler construction

site. For example, it is possible to prepare the alloy coated boiler part free from the thermal shock cracking even when being subjected to weld for joining at that construction site, which the alloy coated boiler part is the same as the product described in claim 1 and is adjusted to the collaboration dimension in such a way that the self-fluxing alloy thermal spraying coated boiler part manufactured in the factory is made to adjust to the collaboration dimension, further, the weld building-up is performed to the end portion where the alloy material (desirably, the second alloy material) of the composition for the end portion is taken to as the filler metal after removal of the coating of the self-fluxing alloy (the first alloy material) of the end portion. Or it is possible to perform repair of the self-fluxing alloy coating by applying the above described pre heating-weld building-up to the coating defect portion (exfoliation portion or the like) in the member which is subjected to the self-fluxing alloy coating (the thermal sprayed coating or un-melted coating).

[0014]

Here, the gradation preheated region prepared before the building-up implementation is capable of being formed with gentle temperature distribution by using procedure of operation to swing appropriately a solenoid coil in the axis line direction thereof upon performing induction heating using the solenoid coil in which winding density is gradually changed in the axis line direction so as to generate a gradient of heat input density in the axis line direction.

The above preheating process is somewhat troublesome work, however, the object region is an extremely narrow range, further, it is sufficed if preparing minimum scale of a high frequency power supply, therefore, it is possible to implement reasonably in a narrow space inside the boiler. By the way, the preheating in this welding method is efficient depending on the induction heating

as described above, however, being not limited to this, it may be substituted by other heating method, such as, for example, gas heating.

[0015]

Above described procedure is significantly effective when rapidly forming and saving beforehand the easily weld jointing alloy coated boiler part described in claim 1 at the boiler construction site.

The above described welding method, further, it is available when intended to perform weld joint of the self-fluxing alloy thermally spraying coated boiler part cut in collaboration dimension without generating thermal shock cracking at all events in stead of preparation at that construction site of the alloy coated boiler part described in the above claim 1; thus it becomes a temporary measure of one article correspondence instead of provision of the alloy coated boiler part described in claim 1.

In the method of welding the self-fluxing alloy coated boiler part described in claim 8, it is desirable that the alloy material (the second alloy material) of the composition for the end portion is set to a filler metal while considering quality requirement (erosion/corrosion resistance) after the welding.

As described above, the second problem is solved.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1(a) is the entire plan view showing structure of an alloy coating boiler part according to an embodiment of the present invention;

Fig. 1(b) is the entire front view/end elevational view showing structure of an alloy coated boiler part according to an embodiment of the present invention;

Fig. 1(c) is an enlarged plan view of the major portion showing structure of an alloy coated boiler part according to an embodiment of the present

invention;

Fig. 1(d) is a principal part enlarged front view/end elevational view showing structure of an alloy coated boiler part according to an embodiment of the present invention;

Fig. 1(e) is A-cross section enlarged view showing structure of an alloy coated boiler part according to an embodiment of the present invention;

Fig. 1(f) is a plurality of joined state plan view showing structure of an alloy coated boiler part according to an embodiment of the present invention;

Fig. 2(a) is the entire plan view showing a manufacturing process of the alloy coated boiler part;

Fig. 2(b) is the entire front view/end elevational view showing a manufacturing process of the alloy coated boiler part;

Fig. 3(a) is an enlarged plan view of the major portion showing a manufacturing process of the alloy coated boiler part;

Fig. 3(b) is an enlarged plan view of the major portion showing a manufacturing process of the alloy coated boiler part;

Fig. 4(a) is an enlarged plan view of the major portion showing a manufacturing process of the alloy coated boiler part;

Fig. 4(b) is a major portion enlarged front view/end elevational view showing a manufacturing process of the alloy coated boiler part;

Fig. 4(c) is the entire plan view showing a manufacturing process of the alloy coated boiler part;

Fig. 4(d) is the entire front view/end elevational view showing a manufacturing process of the alloy coated boiler part;

Fig. 4(f) is the entire front view/end elevational view showing a manufacturing process of the alloy coated boiler part;

Fig. 5(a) is an enlarged plan view of the major portion showing a manufacturing process of the alloy coated boiler part;

Fig. 5(b) is a major portion enlarged front view/end elevational view showing a manufacturing process of the alloy coated boiler part;

Fig. 6(a) is a cross sectional view showing the weld joint portion before the welding of welding process of the alloy coated boiler part;

Fig. 6(b) is an enlarged cross sectional view showing the weld joint portion after welding of welding process of the alloy coated boiler part;

Fig. 7(a) is a plan view of a boiler tube showing a manufacturing process of the alloy coated boiler part according to the other embodiment of the present invention;

Fig. 7(b) is a plan view/end elevational view of a boiler tube showing a manufacturing process of the alloy coated boiler part with respect to the other embodiment of the present invention;

Figs. 7(c) to 7(h) are plan views of a boiler tube showing a manufacturing process of the alloy coated boiler part according to the other embodiment of the present invention;

Figs. 8(a) and 8(b) are plan views of a boiler tube showing a manufacturing process of the alloy coated boiler part according to the other embodiment of the present invention; and

Figs. 9(a) and 9(b) are plan views of major portions of a boiler tube showing a manufacturing process of the alloy coated boiler part according to the other embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0016]

Constitution of one embodiment of the alloy coated boiler part of the present invention will be described while referring to the drawings. Figs. 1(a) to Fig. 1(e) show structure of a boiler furnace panel 10 as the specific example of the alloy coated boiler part, in which Fig. 1(a) is the entire plan view; Fig. 1(b) is the entire front view/end elevational view s; Fig. 1(c) is an enlarged plan view of the major portion; Fig. 1(d) is a principal part enlarged front view/end elevational view; Fig. 1(e) is cross section enlarged view; and Fig. 1(f) is a plurality of joined state plan view.

[0017]

The boiler furnace panel 10 is one in which a super alloy coating 15 (the second alloy material coating) and a self-fluxing alloy coating 16 (the first alloy material coating) are thermally sprayed to a steel panel 11 (a base metal) at a factory beforehand, on the occasion of assembling of the furnace housing, neighboring end portions each other are weld joined while overlapping a plurality of panels at the construction site. That is, a steel panel 11 (plate material-tube material composite panel) is constituted such that, in order to form a base unit of furnace housing with a cooling water passage, a tube portion 12 (tube material) forming a cooling water passage and a plate portion 13 (plate material) forming a joint portion are arranged alternately and these are joined tightly with weld joint or the like, further, for erosion/corrosion resistance, at the one side (portion to be protected) of the housing, being furnace inner wall, except for end portions for weld joint, weld sprayed coating composed of the alloy material is formed on the entire area.

[0018]

In the thermal spraying, the super alloy coating 15 and the self-fluxing alloy coating 16 are used separately for reduction of the cost of material and the

cost of construction, in which the super alloy coating 15 is carried out at belt shaped region (rapid temperature rise region) in the end portions of a tube end side provided to weld joint portion 20 among panel end portions, while the self-fluxing alloy coating 16 is carried out at remaining region among region to be protected. The rapid temperature rise region is a region in which the thermal shock cracking may occur in self-fluxing alloy coating at the time of the weld operation, since the rapid temperature rise region width C differs depending on a steel material shape or coating thickness or the like, it cannot be described sweepingly, but, in the boiler furnace panel, it may be about 15 to 50mm (any of 15mm or more and 50mm or less).

[0019]

Of course, with respect to the end portion of the plate portion 13, the super alloy coating 15 is formed up to inner portion exceeding it. That is, the super alloy coating 15 enters into not only the rapid temperature rise region but also the remaining region which is a region exceeding it while extending up to about two times of the rapid temperature rise region width C. Further, at that position, a thin notching 14 with a width of about 0.5 to 2mm is formed. This secures warping margin for weld aligning of the tube portion 12, and may extend to a degree of several times of the rapid temperature rise region width C together with the super alloy coating 15 of the end portions of the plate portion 13 depending on thickness of the tube portion 12. At end portion surface of the tube portion 12, large chamfer/taper to become a welding groove is provided.

[0020]

The material of the super alloy coating 15 is occupied by an Ni-enriched Ni-Cr component over a half proportion of the alloy material, however, contents of B and Si being melting point lowering elements are suppressed such that B is

0.1% or less and Si is 0.5% or less for avoiding a thermal shock cracking at the time of the welding operation. As standards for stipulating such alloy material, in Japan, there are listed JIS G 4901 for bar material, or JIS G 4902 for plate material, as International standards, there are listed ISO 4955, or ISO 9723. Thickness of the super alloy coating 15 is about 1.2 to 3.0 mm.

[0021]

The material of the self-fluxing alloy coating 16 is occupied by an Ni-enriched Ni-Cr component over a half proportion, and contents of B, Si are set to 1 to 5% (weight ratio) respectively in order that steep rise of material cost is made to suppress and efficient implementation is brought by the thermal spraying process and the melting process. As the alloy material, in Japan, there is listed Nickel self-fluxing alloy material of composition stipulated in a JIS H 8303. In other countries or areas, there is listed Nickel self-fluxing alloy material of composition stipulated in International standards ISO 14920. By the way, as the self-fluxing alloy material, though high price, Co (cobalt) based self-fluxing alloy material or WC (tungsten carbide) mixed self-fluxing alloy material may be used as the need arises. Thickness of the self-fluxing alloy coating 16 is about 1.0 to 2.0 mm.

[0022]

A manufacturing process concerning the boiler furnace panel 10 (alloy coated boiler part) of the embodiment will be described referring to the drawings. Fig. 2(a) is the entire plan view; Fig. 2(b) is the entire front view/end elevational view; Fig. 3(a) is an enlarged plan view of the major portion; Fig. 3(b) is an enlarged plan view of the major portion; Fig. 4(a) is an enlarged plan view of the major portion; Fig. 4(b) is a major portion enlarged front view/end elevational view; Fig. 4(c) is the entire plan view; Fig. 4(d) is the entire front view/end

elevational view; Fig. 4(f) is the entire front view/end elevational view; Fig. 5(a) is an enlarged plan view of the major portion ; and Fig. 5(b) is a major portion enlarged front view/end elevational view.

[0023]

The manufacture of the boiler furnace panel 10, in short, is one in which a steel panel 11 is taken to as a base metal, a super alloy coating 15 is formed on an one side of the steel panel 11, after that, also a self-fluxing alloy coating 16 is formed thereon, and further, end portion shape is finished, being performed in a factory.

The steel panel 11 (see Fig. 2) is preferable in the same as conventional one in which the tube portion 12 and the plate portion 13 composed of steel materials are joined alternately by the weld joint or the like. In the case of ordinary boiler furnace panel, size of the steel panel 11 is in the dimension that length is about 4000 to 6000 mm and width is about 400 to 500 mm, diameter of the tube portion 12 is about 60 to 75 mm, thickness of the tube portion 12 is about 5.0 to 7.0 mm, and thickness of the plate portion 13 is about 5 to 7 mm.

[0024]

Formation of the supper alloy coating 15 concerning the end portion of the steel panel 11 (see Fig. 3), in the tube portion 12, is performed to somewhat wider range than the rapid temperature rise region width C, while, in the plate portion 13, being performed to a portion come further inwardly. By the way, in some cases, the tip of about 50 to 150 mm remains without performing coating process for fixing and keeping of the work during operation, however, at that case, it is cut off at the time of end portion shape finishing. Implementation work of the super alloy coating 15 is performed with the weld building-up, the second alloy material being made into a wire material is suited as a filler metal, above all, in

Japan, the super alloy materials stipulated in JIS G 4901-NCF 625, and JIS G 4902-NCF 625 are suitable, while in other countries or areas, it is possible to select corresponding article from the super alloy materials stipulated in international standards of ISO 4955 or ISO 9723 or the like.

[0025]

Formation of the self-fluxing alloy coating 16 to the remaining region of the rapid temperature rise region (see Fig. 4) is performed in the order of masking of the super alloy coating 15, thermal spraying of the self-fluxing alloy, and melting process of the self-fluxing alloy. By the way, although detailed description is omitted, surface cleaning process such as shot blast and the like is performed appropriately. Masking of the super alloy coating 15 is performed using, for example, a blocking plate such as metal thin plate or the like, or heat-resistant masking tape. Further, the masking is performed such that the super alloy coating 15 is partially overlapped on the self-fluxing alloy coating 16 in order that a base metal is not exposed from a gap formed between the super alloy coating 15 and the self-fluxing alloy coating 16. In such overlapped portion, it is preferable to add taper in thickness of the both coating so that a sudden difference in level does not emerge.

[0026]

Since the thermal spraying and the after melting process for the formation of the self-fluxing alloy coating 16 is preferably performed in such a way as coating formation process to a conventional article with no super alloy coating 15 (for example, see the patent document 2), although detailed description is omitted, it is performed with ordinary procedure by using known apparatus. That is, thermal spraying of the self-fluxing alloy is performed efficiently with ordinary thermal spraying method by using known thermal spraying apparatus. As for the thermal

spraying material of the self-fluxing alloy coating 16, the first alloy material powdered is suited, above all, in Japan, nickel self-fluxing alloy material corresponding to JIS H 8303-SFNi 4 is preferable, in other countries or areas, it is possible to select corresponding article from nickel self-fluxing alloy materials stipulated in the international standards of ISO 14920.

[0027]

Further, basically, the melting process of the self-fluxing alloy is performed efficiently in one direction with ordinary movement heating method by using known high frequency induction heating apparatus.

However, different from the conventional method, sufficient thermal spraying process is made to bring under the condition of one directional movement to the self-fluxing alloy coating 16 thermally sprayed to the plate portion 13 (see patent documents 2, 3).

[0028]

In the case of coating with the above alloy materials, it is preferable to set thickness ratio between the super alloy coating 15 and the self-fluxing alloy coating 16 into 1.2 to 2.0 : 1. This is because wear-resistance of the self-fluxing alloy coating is superior to the super alloy coating, thus, by presetting the coating thickness ratio of the above range depending on conditions, wear-resistant service life of the both coatings are equalized. That is, in less than 1.2 : 1, wear of the super alloy coating 15 precedes, there is a fear that remaining self-fluxing alloy coating 16 becomes useless, on the other hand, exceeding 2.0 : 1, inversely wear of the self-fluxing alloy coating 16 precedes, there is a fear that remaining super alloy coating 15 becomes useless.

[0029]

After formation of the alloy coatings 15, 16 on one side of surface,

un-coated portion of the tip of the steel panel 11 is cut off (see Fig. 5). This is done by a plasma cutting or the like, simultaneously or another time, a notch 14 is formed. Further, chamfering process is carried out at the tip of the tube portion 12 while preparing for weld joint for another boiler furnace panel 10 (see Figs. 1(c), 1(e)).

Thus, when terminating the finishing of the end portion, one of the boiler furnace panel 10 is completed. Further, similarly, when the boiler furnace panel 10 is efficiently manufactured one after another, these are accumulated to be kept in a factory or warehouse or the like.

[0030]

Use state concerning the boiler furnace panel 10 (alloy coated boiler part) of the embodiment will be described referring to the drawings. Since a plurality of boiler furnace panels 10 are assembled into a boiler furnace with the plurality of panels with weld-joining, here, particularly there will be described weld process of the boiler furnace panels 10 each other. Fig. 6(a) is a cross sectional view showing the weld joint portion before the implementation of welding process of the alloy coated boiler part; and Fig. 6(b) is an enlarged cross sectional view showing the weld joint portion after welding of welding process of the alloy coated boiler part. Further, Fig. 1(f) is a plan view showing a joined state of a plurality of the boiler furnace panels 10.

[0031]

Weld joint process comprises positioning (aligning) process, tube end portion weld joint process and plate portion weld joint process, under that order, treatment of each process is applied to weld joint portion 20 of a pair of weld object boiler furnace panels 10. In some cases, this is partially performed in assembling factory, however, this is performed finally in a boiler construction site.

Firstly, in the positioning process (see Fig. 6(a)), both boiler furnace panels 10 are fixed in the state that the tip end portions of tube part 12 to become the weld joint portion 20 are caused to face. Then, if there is position deviation in each tube end portions faced state, and the position deviation is slight one which is generated by formation of the alloy coatings 15, 16, position adjustment of the faced tube end portions is performed by knocking a small wend portion into the notch 14 and the like.

[0032]

Next, in the tube end portion weld joint process (see Fig. 6(b)), annular welding is performed from a tube inner surface side to a tube outer surface side for several times for no generation of voids, and for no overheating. In the shown example, since being separated in five layers, the welding starts from the annular welding of a super alloy welding layer 21 facing on hollowness of the tube, followed by the annular welding of a super alloy welding layer 22 buried with the tube thickness, further, three columns of super alloy welding layers 23, 24 and 25 exposed on the tube outer periphery are carried out sequentially every one round. As for the filler metal used in the tube end portion welding process, the second alloy material as being the super alloy coating 15 is desirable in the point of balance of corrosion resistance, and wear resistance to the self-fluxing coating. The super alloy coating 15 carried out using the second alloy material has no thermal shock cracking sensitivity, therefore, the welding is performed easily and accurately without injuring the coating. Further, as for the self-fluxing alloy coating 16 ahead of it, though having the thermal shock cracking sensitivity, since the super alloy coating 15 covers the rapid temperature rise region width C, also, it is not necessary for concerning a generation of cracking.

[0033]

Finally, in the plate portion weld joint process, although illustration is omitted, an application plate with a size for covering at least both notches 14 is welded while extending over the plate portion 13 of the both boiler furnace panels 10. The welding of the application plate is performed from the other side (that is, un-formed surface of the super alloy coating 15, furnace outer wall surface or unprotected surface). The notch 14 is thin and further change of the application plate is easy, therefore, in some cases, process is terminated by leaving inner side of the notch 14 in the state of the base metal as it is, that is, the inner side of the notch 14 is left such that the steel panel 11 is exposed, however, it may be preferable to fill up in the notch 14 with the welding while using the second alloy material as being the super alloy coating 15 as the filler metal. Further, as for the plate portion 13, different from the tube portion 12, since the repair after the boiler construction is easy to perform (even the repair being performed from outside the boiler, rough object can be achieved), it may be adopted the procedure that, after realizing long service life while thickening a panel end portion plate or plate thickness of the application plate, the alloy coating is omitted.

[0034]

Thus, the boiler furnace panel 10 is joined to one after another (see Fig. 1(f)), the furnace housing with cooling water passage is completed.

[0034]

In such a furnace housing, the entire region concerning the entire surface of inner wall, or portion to be protected of the inner wall surfaces, are covered with close alloy coating, thereby, erosion/corrosion resistance is improved significantly.

[0035]

Next, processes concerning one embodiment of the method of welding

the self-fluxing alloy coated boiler part of the present invention will be described referring to the drawings. Fig. 7(a) is a plan view of a boiler tube; Fig. 7(b) is a plan view/end elevational view of a boiler tube; Figs. 7(c) to 7(h) are plan views of a boiler tube; and Figs. 8(a) and 8(b) are plan views of a boiler tube.

[0036]

Here, there will be described supplying method of the boiler tube at the construction site which the boiler tube is not prepared beforehand. Provided that the steel boiler tube 70 subjected to the self-fluxing alloy coating on outer circumferential surface being a portion to be protected (see Figs. 7(a), 7(b)) can be obtained rapidly, however, its length does not agree with the assembling portion (see Fig. 7(c)). Further, the self-fluxing alloy coating is alloy material occupied by Ni-enriched Ni-Cr component over a half proportion of the alloy material, and in which B and Si are mixed in the range of 1 to 5% respectively, that is, the self-fluxing alloy coating is the first alloy material (above described material of the self-fluxing alloy coating 16) having the thermal shock cracking sensitivity, when it is welded in the state that self-fluxing alloy coating 16 is left as it is, the welding becomes not desired state.

[0037]

Accordingly, an adaptation portion with required length is made to remain by cutting off a surplus portion 71 from the boiler tube 70 (see Fig. 7(d)), for after weld joint (see Fig. 8(b)), firstly, performed is the welding of the weld building-up at both end portions of the adaptation portion 72 being the adoption portion (see Figs. 7(e) to 7(h), and Fig. 8(a)). The process order of the welding is described in detail, firstly, the self-fluxing alloy coating is removed from the both end portions 73, 74 within the adaptation portion 72 (see Fig. 7(e)). The base metal exposed width of the end portions 73, 74 are the same as the above described rapid

temperature rise region width C, though cannot be described indiscriminately, being about 15 to 50 mm.

[0038]

After that, an induction coil 75 configured such that the coil 75 is wound in a solenoid shape and its winding pitch increases monotonously (see Fig. 7(f)) is made to connect to the high frequency induction heating apparatus; the end portion 73 is inserted to be fitted with freedom into the coil 75 (see Fig. 7(g)), to perform preheating process due to induction heating. At this time, an induction coil 75 which has a length of 2 to 3 times of base metal exposed width in the end portion 73 is used, where rough portion of the winding pitch is set to an intermediate portion side of the adaptation portion 72 while dense portion of the winding pitch is set to the end portion 73 side between both end portions of the induction coil 75. Further, energizing condition of the induction coil 75 set on the high frequency induction heating apparatus is made a gradual speed heating condition that a temperature raising speed in the end portion 73 becomes 2 to 10°C.

[0039]

Then, the adaptation portion 72 is preheated slowly with heating pattern where the amount of temperature rise gradually decreases inwardly from the end portion 73. Subsequently, if the temperature of the maximum temperature portion becomes 450 to 600°C, the heating ends. By this means, "gradation preheated region" with no sudden change in a respect of space in axial direction and in respect of elapse of time is formed, therefore, consecutively, that is, swiftly before being cooled, the super alloy coating 76 is formed at the end portion 73 of the adaptation portion 72 (see Fig. 7(h)). The formation is performed such that, with the weld building-up, no base metal exposed surface is made to leave at the

position between the self-fluxing alloy coating and the super alloy coating 76.

[0040]

Further, in the weld building-up, the second alloy material (above described the material of the super alloy coating 15) with no thermal shock cracking sensitivity is used as the filler metal. That is, the alloy material occupied by an Ni-enriched Ni-Cr component over a half proportion of the alloy material and contents of B and Si being melting point lowering elements are suppressed such that B is 0.1% or less and Si is 0.5% or less is taken to as the filler metal, and the welding is performed.

In such a welding, previous formation is the self-fluxing alloy coating, and after formation is the super alloy coating, however, the welding is carried out within the "gradation preheating region", therefore, there is no chance of cracking the self-fluxing alloy coating.

[0041]

Thus, the adaptation portion 72 of the boiler tube 70 is constituted such that, as for the end portion 73 being an object region of the later weld joint, the super alloy coating by the second alloy material is formed extending over the rapid temperature rise region, and, at the inner remaining region from the super alloy coated region, the self-fluxing alloy coating is left. Then, if the same welding is performed with respect to the remaining end portion 74, the corresponding boiler tube 80 to the boiler furnace panel 10 described above is completed (see Fig. 8(a)). Also the other tubes 81, 82 joined to the boiler tube 80 are prepared similarly at the construction site if necessary, and then being kept temporarily.

[0042]

Then, at the time of the weld joint, the boiler tubes 80, 81 and 82 as being joining object are arranged at the construction site, after performing the

required pipe end portion treatment such as formation of the welding grooves, the boiler tubes 80, 81 and 82 are made to fix with the condition that the tips of the boiler tubes 80, 81 and 82 are oppositely faced to each other at the weld joint portions 83, 84 (see Fig. 8(b)). Then, the weld joint of the pipe end portions is performed to the respective weld joint portions 83, 84 while using the same filler metal used for the weld building-up of the super alloy coating 76. The tube end portion weld joint of the boiler tube 80, like the tube end portion weld joint of the tube portion 12 described above, can be performed easily without a concern of the thermal shock cracking of the self-fluxing alloy coating, and the preheating is not necessary.

[0043]

Processes concerning the other embodiment of the method for welding the self-fluxing alloy coated boiler part of the present invention will be described referring to the drawings. Figs. 9(a) and 9(b) are plan views of major portions of a boiler tube.

[0044]

Here, there will be described the weld joint method when it becomes necessary to perform the weld joint of the steel boiler tubes 90 subjected to the self-fluxing alloy coating on the outer circumferential surface at the construction site in a hurry. Here, also, since the self-fluxing alloy coating is alloy material occupied by Ni-enriched Ni-Cr component over a half proportion of the alloy material, and in which B and Si are mixed in the range of 1 to 5% respectively, that is, the self-fluxing alloy coating is the first alloy material (above described material of the self-fluxing alloy coating 16) having the thermal shock cracking sensitivity, when it is welded in the state that self-fluxing alloy coating 16 is left as it is, the welding becomes not desired state, there is performed formation of the

"gradation preheated region" by using the high frequency induction heating apparatus.

[0045]

Reasonably, the preheating of this case, different from the above described respective embodiments, is performed immediately before the weld joint. Further, in many cases, the both boiler tubes 90 of the joining object are already fixed at the construction site, and it is difficult to separate the both end portions 91. For that reason, it is preferable that the end portion 91 is subjected to pre-processing of forming the weld grooves, while, for the induction coil 92, one-turn article capable of acting in deployment, and put on and taken off is adopted (see Fig. 9(a)). Then, when performing the heating for formation of the "gradation preheated region" while high frequency energizing the induction coil 92, the induction coil 92 is caused to reciprocate.

[0046]

The reciprocating movement is performed many times until the temperature of the maximum temperature portion arrives at 450 to 600°C. Further, the heating is performed at the region of the end portion 91 in gradual speed, to the contrary, with being separated from the end portion 91 in rapid speed, in order that the heating pattern becomes a pattern where the amount of temperature rise gradually decreases with heading toward the both directions, with the end portion 91 of the weld joint object as the center, that is, the heating pattern becomes a pattern where the amount of temperature rise gradually decreases with heading inwardly in longitudinal direction of the boiler tube 90 from the end portion 91. The reciprocating distance, at one side, that is, with respect to one boiler tube 90, of about 15 to 50 mm is secured inwardly from the end portion 91. Further, in this case also, energizing condition of the induction coil 92

set to the high frequency induction heating apparatus is set to gradual speed heating condition such that the temperature raising speed in the end portion 91 becomes 2 to 10°C/sec.

[0047]

Then, also in this case, "gradation preheated region" with no sudden change in respect of space in axial direction and in respect of elapse of time is formed, therefore, consecutively, faced end portions 91 of the boiler tube 90 are made to perform weld joint swiftly (see Fig. 9(b)). The weld joint of the weld joint portion 93, like the tube end portion weld joint of the tube portion 12 described above, is performed in which the second alloy material (above described material of the super alloy coating 15) with no thermal shock cracking sensitivity is taken to as the filler metal. That is, in this case also, the filler metal is the alloy material occupied by an Ni-enriched Ni-Cr component over a half proportion thereof and contents of B and Si are suppressed such that B is 0.1% or less and Si is 0.5% or less, however, since the gradation preheating precedes immediately before, there is no case where the self-fluxing alloy coating is cracked.

[0048]

The others, in the above described respective embodiments, as the specific example, production in the factory of the boiler furnace panel 10 and obtaining in construction site of the boiler tube 80 are described, however, there may be the reverse. That is, like the above description, also production of the boiler tube 80 in the factory, and obtaining the boiler furnace panel 10 in the construction site are appropriately performed, though the detailed description as being repetition is omitted.

Description of the Symbols

[0050]

10 Boiler furnace panel (Alloy coated boiler part)

11 Steel panel (Composite panel)

12 Tube portion (Tube material)

13 Plate portion (Plate material)

14 Notch

15 Super alloy coating (Weld building-up portion, The second alloy material coating)

16 Self-fluxing alloy coating (After-thermally sprayed melting portion, The first alloy material coating)

20 Weld joint portion

21 to 25 Super alloy welding layer (The second alloy material filler metal)

40 Induction coil (High-frequency induction heating apparatus)

70 Boiler tube (Self-fluxing alloy coated boiler part)

71 Surplus portion

72 Fitting portion (Adoption portion)

73, 74 End portion (Rapid temperature rise region)

75 Induction coil (High-frequency induction heating apparatus)

76 Super alloy coating (Weld building-up portion, The second alloy material coating)

80 to 82 Boiler tube (Alloy coated boiler part)

83, 84 Weld joint portion

90 Boiler tube (Self-fluxing alloy coated boiler part)

91 End portion

92 Induction coil (High-frequency induction heating apparatus)

93 Weld joint portion

FIG. 9(a)

GRADUAL SPEED

RAPID SPEED